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RESEARCH ARTICLE

THE DESIGN OF AN EYE-PROTECTION DESK LAMP BASED ON STM32

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Abstract

In this paper, we design an intelligent eye-protection desk lamp based on the STM32 chip. The lamp uses a human body infrared sensor to detect the presence of a person near the lamp. It employs ultrasonic waves and a photoresistor to calculate the distance between the person and the lamp, and to gather information about the surrounding light. A voice module is used to broadcast prompt messages. This design enables the lamp to automatically switch on and off, correct the user's sitting posture, adjust its brightness automatically, and provide rest prompts.

Introduction:-

In the current era of rapid electronic technology development, an increasing number of teenagers are experiencing myopia. Investigations have found that contemporary teenagers often have a large amount of homework and frequently study late into the night, maintaining the same brightness when using a desk lamp. This can significantly impact vision. Additionally, non-standard sitting postures can also lead to vision decline. To protect the visual health of teenagers, this paper conducts in-depth research into the design and implementation of intelligent eye-care desk lamps.

This paper primarily focuses on the design of an intelligent eye-protection desk lamp based on STM32. The system uses a microcontroller as the core controller, working in conjunction with sensors. Combined with buttons, a display, and a voice broadcasting module, the system achieves intelligent eye protection for desk lamps.

Overall System Design

The system's hardware modules include: an STM32F103C8T single-chip microcomputer, a human body infrared detection module, an automatic optical module, an ultrasonic distance measurement module, a voice broadcast module, a key module, an LED lighting module, and an OLED display module. The system's software is programmed in the KEIL5 environment. The overall design scheme is depicted in Figure 1.

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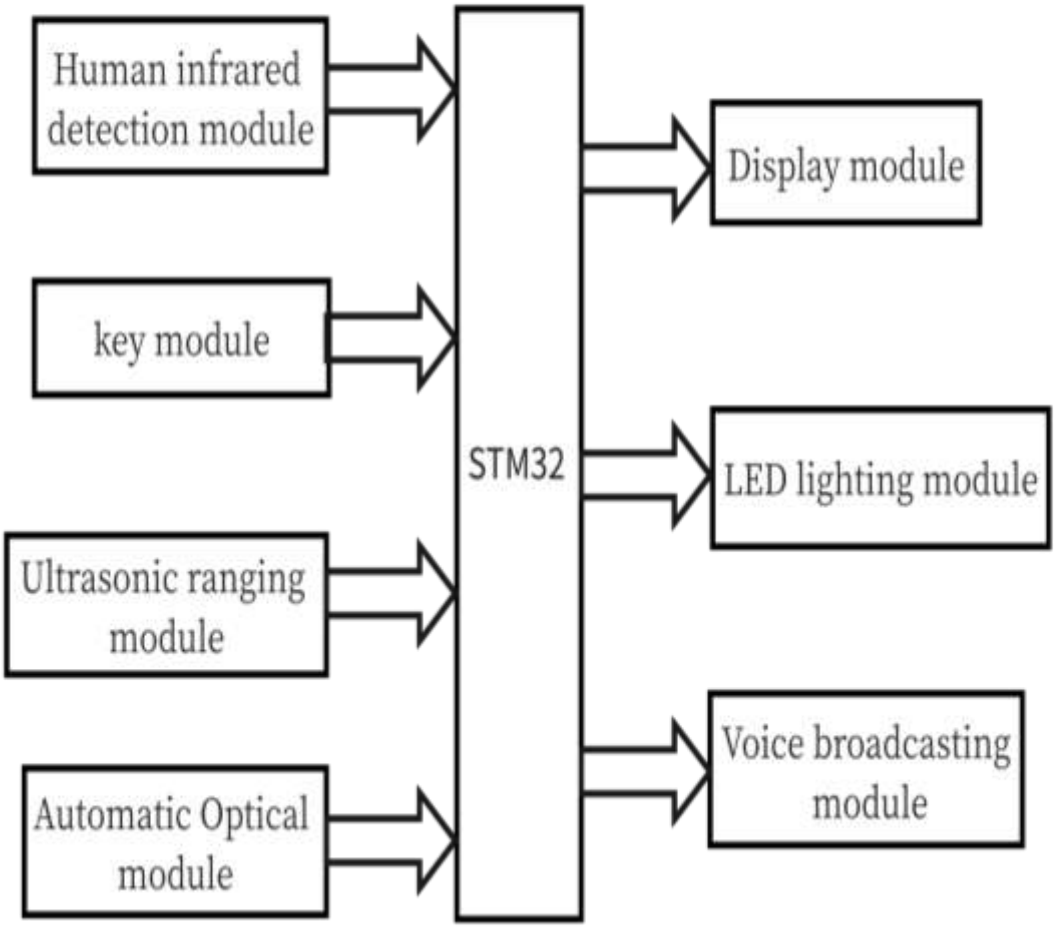

Figure 1:- The overall design of the overall design.

System Hardware Design

The hardware design of the system incorporates several components. The core of the system is the STM32F103C8T6 single-chip microcomputer. The system also includes a human body infrared detection module for sensing the presence of a person, an automatic optical module for adjusting light intensity, and an ultrasonic distance measurement module for calculating the distance between the person and the lamp. Additionally, a voice broadcast module is used for audible notifications, a key module for user inputs, an LED lighting module for illumination, and an OLED display module for visual feedback and interaction. These components work together to create an intelligent, user-friendly desk lamp system.

STM32F103C8T6 MCU

The STM32F103C8T6 microcontroller, which is the heart of the system, is a 32-bit microcontroller equipped with features such as USB, CAN, 7 timers, 2 ADCs, 9 communication interfaces, and 48 pins. Its most notable characteristic is its strong anti-interference capability, making it widely applicable in household appliances, instruments, computer peripherals, and other fields.The primary reasons for selecting the STM32 as the system's overall controller are its comprehensive functionality, flexibility for code writing, superior performance, and stable operation. Additionally, it offers low power consumption, low cost, compact size, and mature technology. Considering these advantages, the STM32 has found extensive use across various fields.Moreover, due to its popularity, many people are familiar with this chip, making it an ideal choice for the system control part of our design. The minimum system pin configuration is depicted in Figure 2.

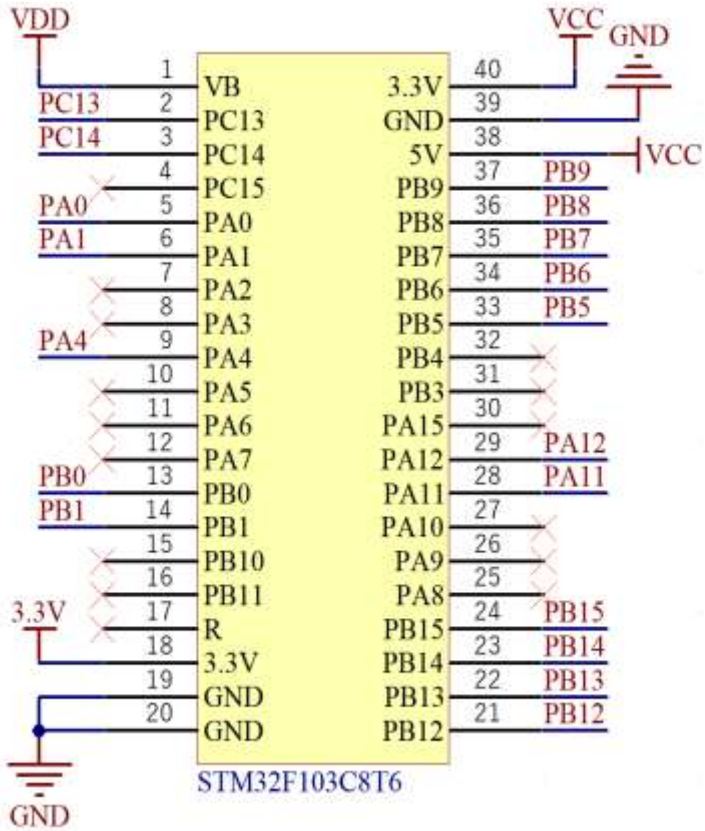

Figure 2:- The minimum system pin configuration of STM32F103C8T6.

Human infrared detection module design

The human body sensing module is a crucial functional module in the entire design, controlling the automatic switching on and off of the light. The HC-SR505 human body sensing module, from a sensory perspective, is quite compact in size. It operates based on infrared technology and is an automatic control product often used in various automatic induction equipment, especially in automatic control products powered by dry cells. This is due to its high sensitivity, strong reliability, ultra-small volume, and ultra-low voltage working mode. The circuit schematic diagram is depicted in Figure 3.

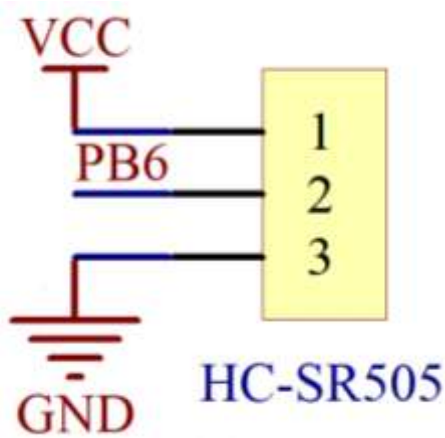

Figure 3:- The circuit schematic diagram of HC-SR505.

Automatic Optical module

The automatic optical module in the design adjusts the brightness level of the LED lights according to the brightness of the surrounding environment. The photosensitive sensor 5506 is a type of sensor that can convert optical signals into electrical signals, thereby changing the brightness. It operates on the principle that the photoresistor changes its resistance value due to changes in light intensity, and sends an analog signal of light intensity to the core. As the light intensity increases, its resistance decreases; conversely, as the light intensity weakens, its resistance increases. The voltage across its resistance is converted into a 0-5V voltage that can be accepted by the digital-to-analog converter.

The 5506 sensor has been in use in the market for many years, with mature technology and proven reliability. Moreover, it is cost-effective, stable in performance, compact in size, and highly sensitive, making it very suitable for this design. The circuit schematic diagram of the Photoresistor 5506 is depicted in Figure 4.

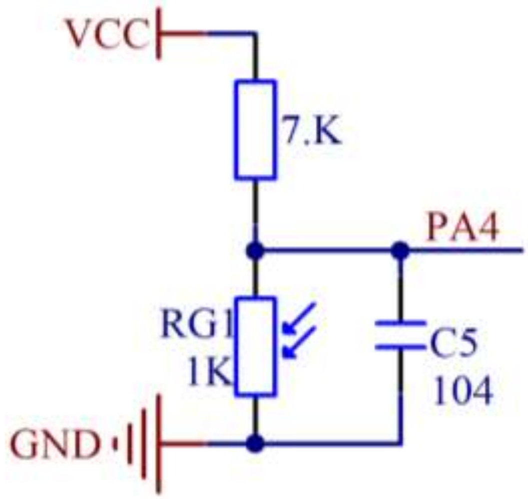

Figure 4:-The circuit schematic diagram of Photoresistor 5506.

Ultrasonic module

The ultrasonic ranging module plays a crucial role in broadcasting and correcting irregular sitting postures. It is a non-contact distance sensing technology with a measurement accuracy of 3mm. This module comprises three parts: an ultrasonic transmitter, a receiver, and a control circuit. It has four pins: VCC, Trig, Echo, and GND (in the schematic diagram, Trig is connected to PA1, Echo is connected to PA0).

The Trig pin triggers distance measurement; a high level of at least 10 μs on this pin will cause the module to automatically send eight 40KHZ ultrasound pulses and detect whether there is a returned signal. If there is a return signal, the Echo pin will output a high level. At this point, the actual distance can be obtained through a formula. The circuit schematic diagram of the ultrasonic ranging module HC-SR04 is depicted in Figure 5.

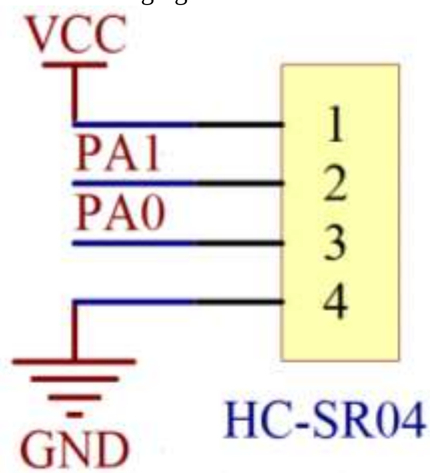

Figure 5:- The circuit schematic diagram ofHC-SR04.

Voice broadcasting module

The JQ8900 voice broadcasting module is a voice chip with a microcontroller core, which communicates with the microcontroller through a serial port. It is multifunctional, offers good sound quality, has a wide application range, and provides stable performance. These advantages make it more versatile compared to other voice chips.

The JQ8900 also features five control modes: button control mode, MP3 control mode, parallel control mode, button combination control mode, and front-line serial port control mode. It can automatically generate instructions, saving development engineers a significant amount of debugging time, which can be quite convenient. Its compact size allows it to be widely used in more precise devices. The schematic diagram of the JQ8900 voice broadcasting circuit is depicted in Figure 6.

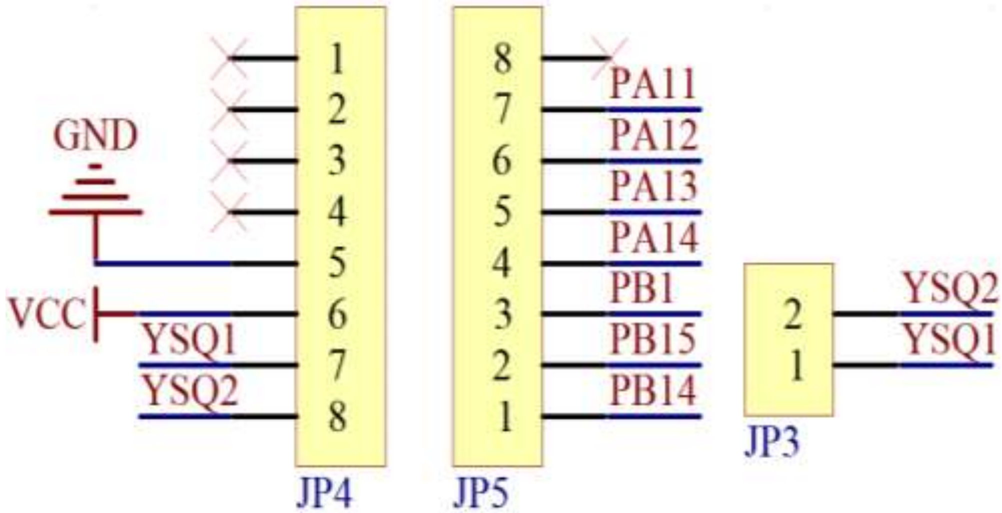

Figure 6:-The schematic diagram of JQ8900.

System software design

The software for this design is programmed in C language. The code is compiled and debugged in the Keil uVision5 software environment, enabling the various modules of this design to operate in a coordinated manner and achieve the complete functionality of the entire system. This approach ensures that all components work together seamlessly, providing an efficient and user-friendly experience.

Overall Program Design

Upon connecting to the power supply, the button module is used to select the control mode. In manual mode, the light can be turned on, off, and the brightness level can be adjusted by pressing the button.

In automatic mode, the process is as follows:

1) The infrared human body detection module first checks for the presence of people. If no one is detected, the light remains off.
2) If someone is detected near the light, it automatically turns on.
3) Once the light is on, the automatic optical system begins to work. It assesses the surrounding light level and adjusts the lamp's brightness accordingly. The voice system broadcasts the current brightness level.
4) Simultaneously, the ultrasonic ranging system starts monitoring the user's sitting posture in real-time. If the user is too close to the lamp, the voice broadcasting system issues a warning.
5) When the countdown time set in the display system ends, the voice system prompts the user to take a break.

The main program flowchart of the system is depicted in Figure 7.

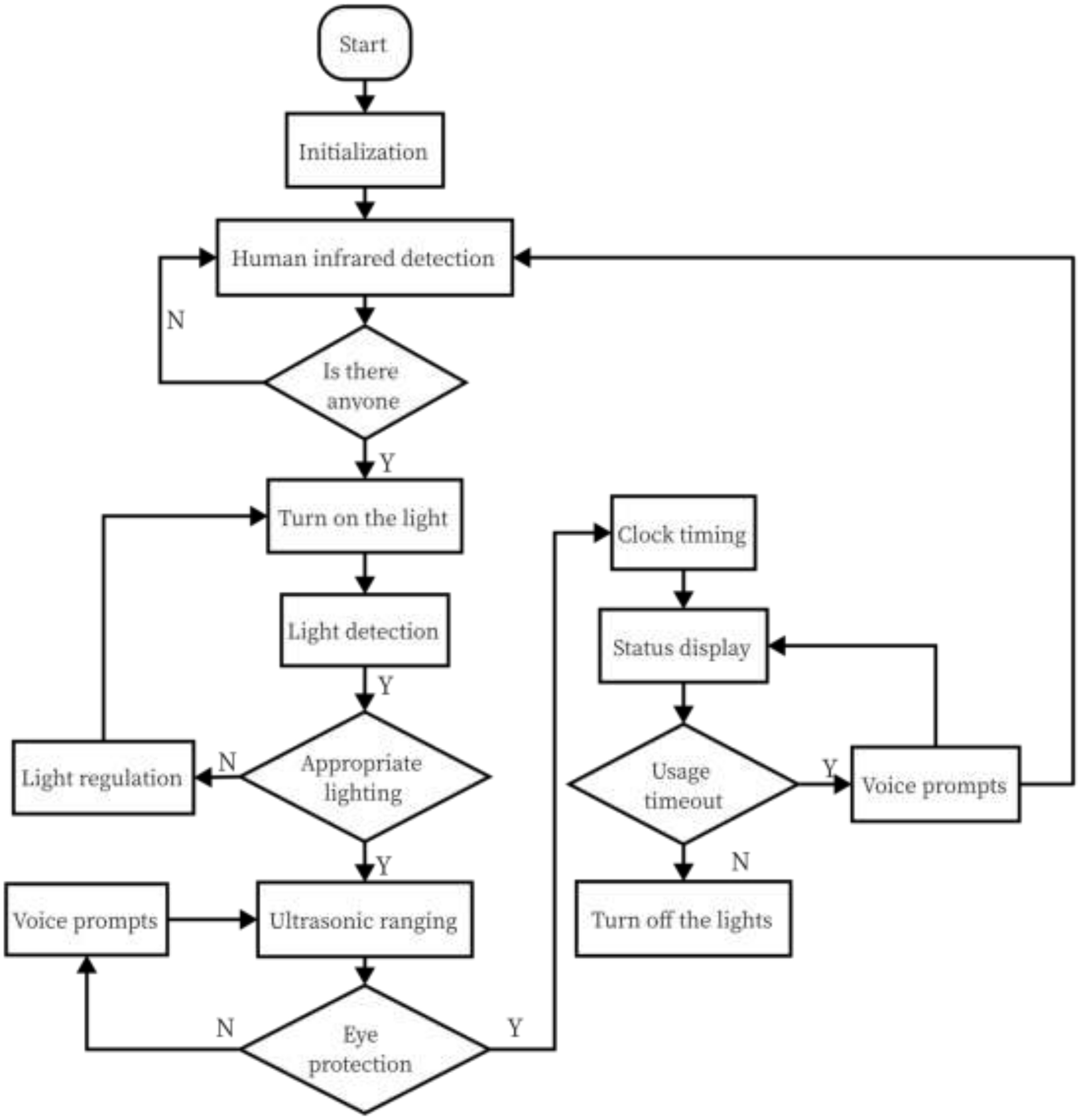

Figure 7:-The main program flowchart of the system

Design of Automatic Photosystem

The system primarily collects external light intensity through the photoresistor, which converts the external light signal into an electrical signal via the photoelectric conversion circuit. The ADC reads the voltage and converts it into PWM. The photoresistor changes its resistance value with the light intensity, ultimately enabling the adjustment of light brightness. The flowchart of the automatic optical system is depicted in Figure 8.

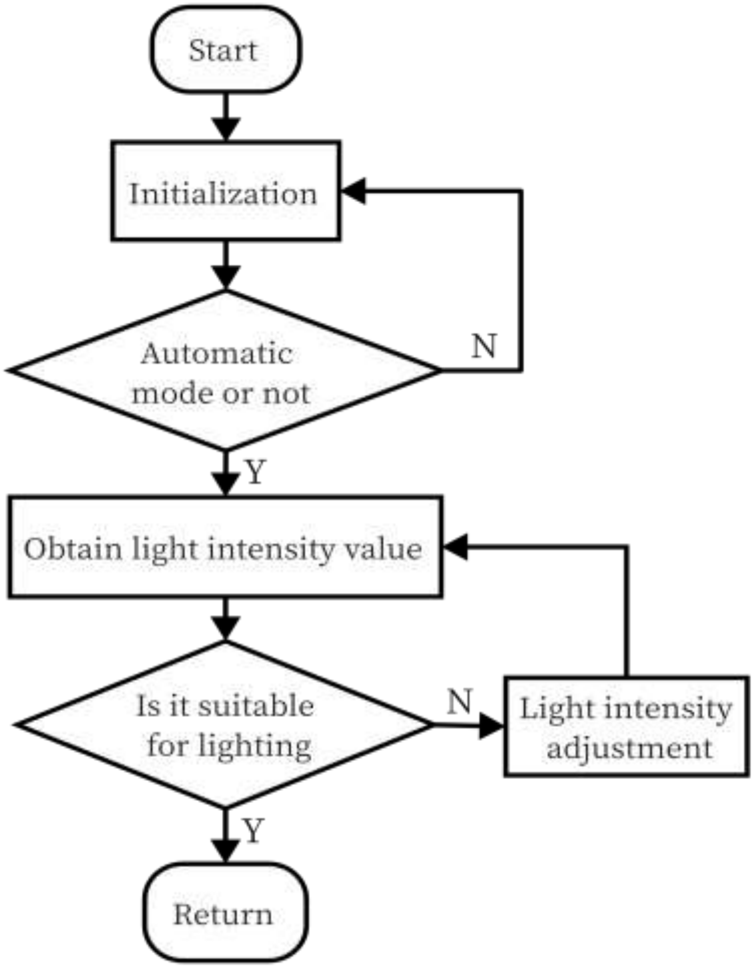

Figure 8:- The flowchart of automatic photosystem.

Design of Human Infrared Detection System

This part of the system uses infrared emitting diodes and infrared receiving transistors to determine whether there is someone under the lamp. This information is used to control the relay's on and off states, thereby achieving automatic control of the desk lamp. The control circuit can be divided into two parts: detection and driving. The detection part is primarily composed of an infrared emitting diode, an infrared receiving transistor, and a current limiting resistor. The flowchart of the human infrared detection system is depicted in Figure 9.

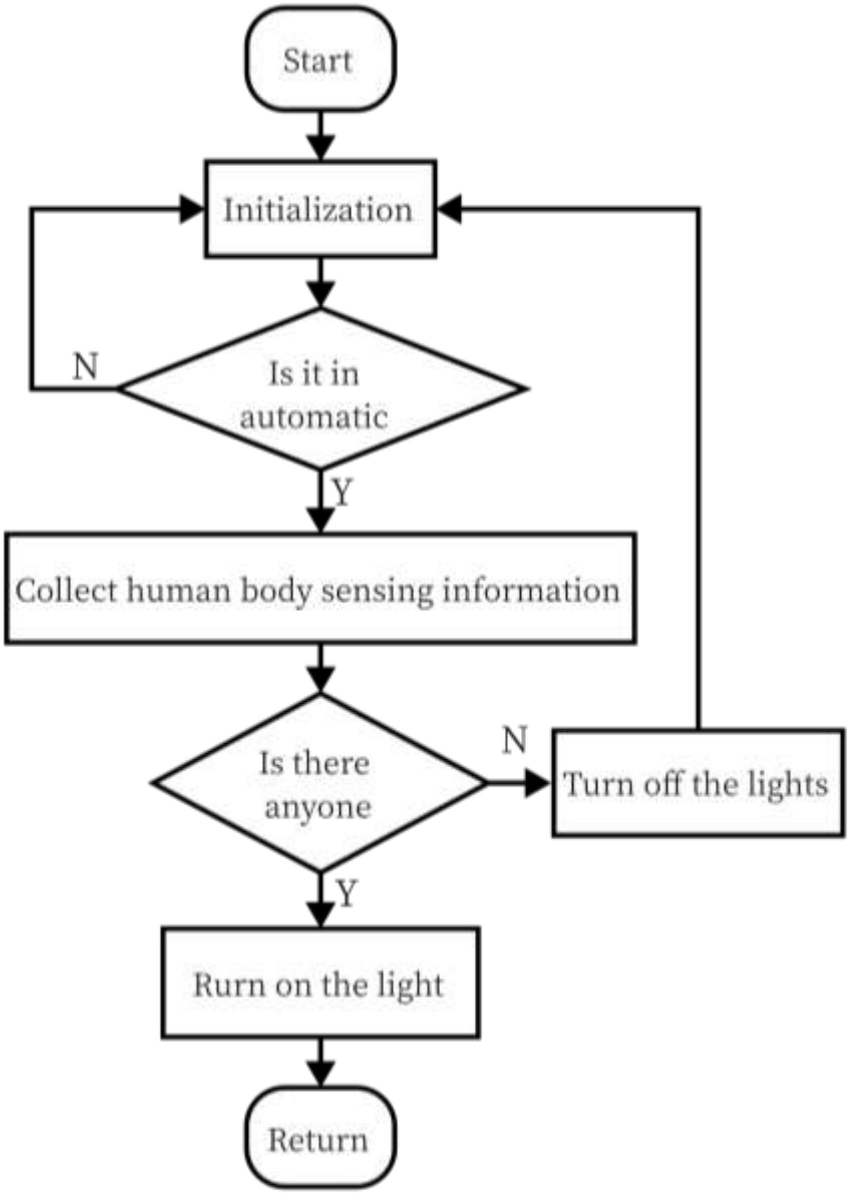

Figure 9:- The flowchart of human infrared detection.

Design of Ultrasonic Distance Measurement System

This part of the system primarily detects the distance between the person and the lamp. If the distance between the person and the lamp is less than a set distance, the voice broadcasting system will announce "abnormal sitting posture". If the distance between the person and the lamp is greater than the set distance, the desk lamp will operate normally without any broadcast. The flowchart of the ultrasonic ranging system is depicted in Figure 10.

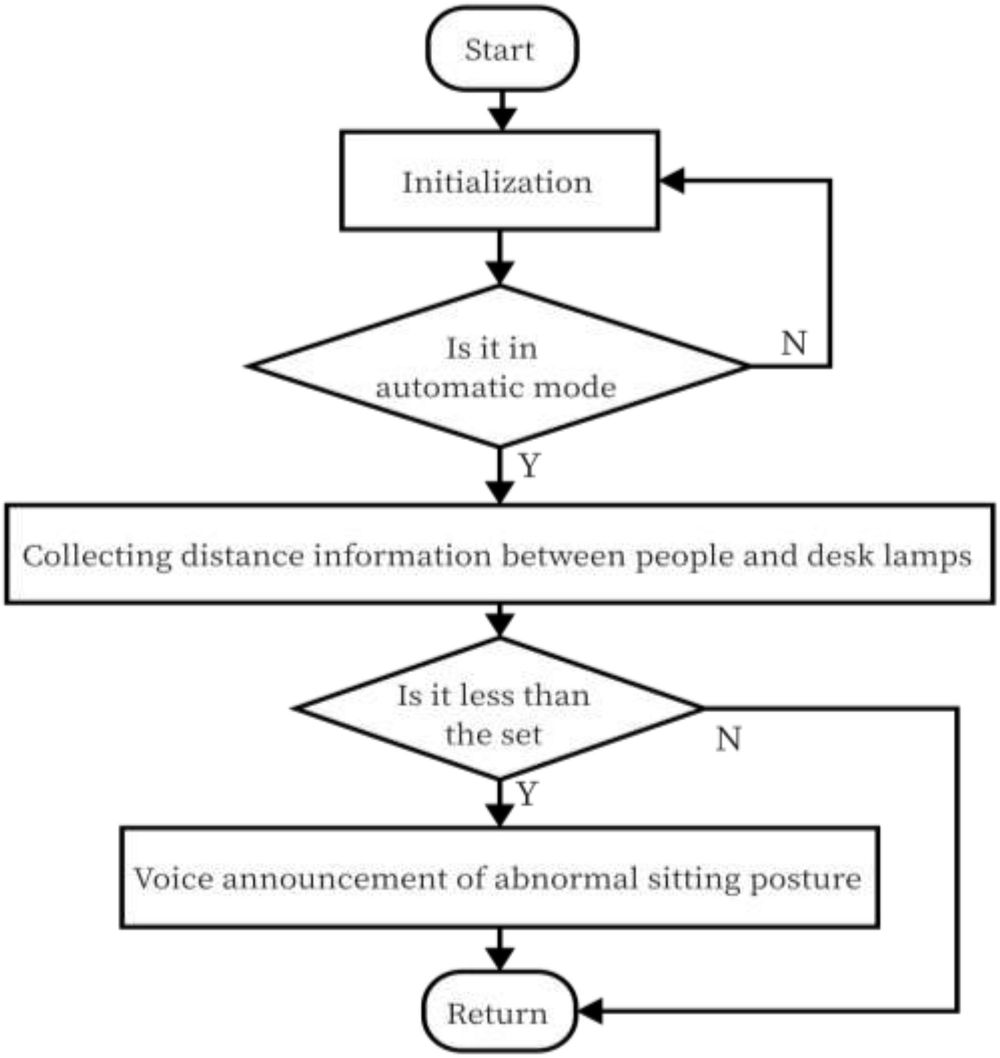

Figure 10:- The flowchart of the ultrasonic ranging system.

Conclusion:-

This article explores the design of an intelligent eye-protection desk lamp based on the STM32 microcontroller. The design employs a human infrared sensor to detect the presence of a person near the desk lamp, enabling automatic switching on and off of the lamp. This achieves the function of "the lamp turns on when people come, and off when people go". The system corrects sitting posture by using ultrasound to measure whether the distance between a person and a desk lamp is less than the eye protection distance. The brightness value is collected by a photoresistor, and the brightness is adjusted through A/D conversion and PWM dimming. However, there are still some issues with the desk lamp that need to be improved. For instance, when a person remains motionless under the desk lamp for a long time but does not fall asleep, the desk lamp automatically turns off the light, which can affect the normal use of the desk lamp. This situation occurs because infrared sensors cannot detect constant infrared radiation. To address this issue, a motor and base can be installed to rotate the Fresnel lens and controller in reverse to actively detect human body signals.Intelligent eye-protection desk lamps are becoming more intelligent and can protect people's vision, making their lives more convenient.

References:-

[1] Deniel, J. M. ,&Thommet, S. . (2022). Occupational eye protection using augmented reality: a proof of concept. Radioprotection.

[2] Taylor, D. L. . (2021). Fog-reducing apparatus for eye protection equipment. US20210315739A1.

[3] Rui, L. I. . (2022). Eye-protection mode processing method, device, terminal and computer-readable storage medium in fingerprint recognition mode. US11275924B2.
[4] Ma, J. , Guo, H. , Rong, S. , Feng, J. , & He, B. . (2023). Infrared dim and small target detection based on background prediction. Remote Sensing.
[5] Zhang, H. , Li, J. , Liu, S. , & Wang, W. . (2023). A human body infrared image recognition approach via dca-net deep learning models. International Journal on Artificial Intelligence Tools.
[6] Marra, A. R. , Edmond, M. B. , Popescu, S. V. , & Perencevich, E. N. . (2021). Examining the need for eye protection for coronavirus disease 2019 (covid-19) prevention in the community. Cambridge University Press.
[7]Peter.Jüni, Costa, B. R. D. , Bobos, P. , Bodmer, N. S. , &Mcgeer, A. . (2021). Revisiting the evidence for physical distancing, face masks, and eye protection. Lancet.
[8]BS EN ISO 18526-1-2020.Eye and face protection. Test methods. Geometrical optical properties.
[9] Ngamakeur, K. ,Yongchareon, S. , Yu, J. , & Islam, S. . (2023). Passive infrared sensor dataset and deep learning models for device-free indoor localization and tracking. Pervasive and Mobile Computing.
[10] Fujisawa, D. , Nakanishi, J. , &Onakado, T. . (2020). Infrared sensor device including infrared sensor substrate and signal processing circuit substrate coupled to each other. US10847567B2.
[11] Liu Jian. (2023).Design of static human presence sensor based on pyroelectric infrared sensor. Sensor World.
[12] Liu Yanfeng.(2023).Intelligent desk lamp control system based on STM32 microcomputer.Industrial Control Computer.
[13] YangAnqian,ChenXiangping. (2020).Design of intelligent multifunction table lamp system based on STM32. Intelligent Computer and Applications.
[14] Cao Huan. (2022). Design of led table lamp with stable and adjustable illumination based on STM32. China Computer & Communication.
[15] Jun-Wei, T. , Qing-Lin, X. , Bo, Z. ,et.al. . (2015). A design of eye protection table lamp. Electronic Design Engineering.
[16]Xingjiong, X. U. . (2019). Integral design of iron-absorbing table lamp based on autodesk inventor. Modern Information Technology.